

AD-A265 602



NOTATION PAGE

Form Approved
OPM No. 0704-0188

2

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the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington
Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Information and Regulatory Affairs, Office of

1. AGENCY USE ONLY (Leave Blank)

2. REPORT DATE

3. REPORT TYPE AND DATES COVERED

Final: 18 Sep 92

4. TITLE AND SUBTITLE

Validation Summary Report: U.S. NAVY, AdaVAX, Version 5.5 (/OPTIMIZE),
VAXstation 4000 (host & target), 920918S1.11270

5. FUNDING NUMBERS

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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REPORT NUMBER

NIST92USN500_1_1.11

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Ada Joint Program Office
United States Department of Defense
Pentagon, RM 3E114
Washington, D.C. 20301-308110. SPONSORING/MONITORING AGENCY
REPORT NUMBER

11. SUPPLEMENTARY NOTES

DTIC
ELECTE
JUN 03 1993
S E D

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

U.S. NAVY, AdaVAX, Version 5.5 (/OPTIMIZE), VAXstation 4000, (running VAX/VMS Version 5.5) (host & target), ACVC
1.11

93-12443



14. SUBJECT TERMS

Ada programming language, Ada Compiler Val. Summary Report, Ada Compiler Val.
Capability, Val. Testing, Ada Val. Office, Ada Val. Facility, ANSI/MIL-STD-1815A, AJPO.

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION
OF REPORT
UNCLASSIFIED18. SECURITY CLASSIFICATION
UNCLASSIFIED19. SECURITY CLASSIFICATION
OF ABSTRACT
UNCLASSIFIED

20. LIMITATION OF ABSTRACT

AVF Control Number: NIST92USN500_1_1.11

DATE COMPLETED

BEFORE ON-SITE: 1992-08-21

AFTER ON-SITE: 1992-09-18

REVISIONS: 1992-10-27

DTIC QUALITY INSPECTED 2

Ada COMPILER
VALIDATION SUMMARY REPORT:
Certificate Number: 920918S1.11270
U.S. NAVY
AdaVAX, Version 5.5 (/OPTIMIZE)
VAXstation 4000 => VAXstation 4000

| | |
|--------------------|--------------------------------------------|
| Accession For | |
| NTIS CRA&I | <input checked="checked" type="checkbox"/> |
| DTIC TAB | <input type="checkbox"/> |
| Unannounced | <input type="checkbox"/> |
| Justification | |
| By | |
| Distribution / | |
| Availability Codes | |
| Dist | Avail and/or Special |
| A-1 | |

Prepared By:
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AVF Control Number: NIST92USN500_1_1.11

Certificate Information

The following Ada implementation was tested and determined to pass ACVC 1.11. Testing was completed on September 18, 1992.

Compiler Name and Version: AdaVAX, Version 5.5 (/OPTIMIZE)

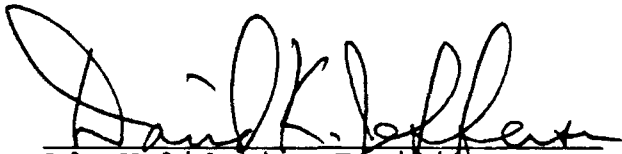
Host Computer System: VAXstation 4000, running VAX/VMS
Version 5.5

Target Computer System: VAXstation 4000, running VAX/VMS
Version 5.5

A more detailed description of this Ada implementation is found in section 3.1 of this report.

As a result of this validation effort, Validation Certificate 920918S1.11270 is awarded to U.S. NAVY. This certificate expires on 2 years after ANSI/MIL-STD-1815B is approved by ANSI.

This report has been reviewed and is approved.



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DECLARATION OF CONFORMANCE

The following declaration of conformance was supplied by the customer.

DECLARATION OF CONFORMANCE

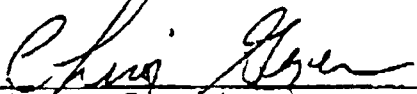
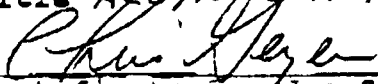
Customer: U.S. NAVY
Certificate Awardee: U.S. NAVY
Ada Validation Facility: National Institute of Standards and
Technology
Computer Systems Laboratory (CSL)
Software Validation Group
Building 225, Room A266
Gaithersburg, Maryland 20899
ACVC Version: 1.11

Ada Implementation:

Compiler Name and Version: AdaVAX, Version 5.5 (/OPTIMIZE)
Host Computer System: VAX STATION 4000, running VAX/VMS
Version 5.5
Target Computer System: VAX STATION 4000, running VAX/VMS
Version 5.5

Declaration:

I the undersigned, declare that I have no knowledge of deliberate deviations from the Ada Language Standard ANSI/MIL-STD-1815A ISO 8652-1987 in the implementation listed above.


Customer Signature
Company U.S. Navy
Title *AL5/N CCS Mgr.*

Certificate Awardee Signature
Company U.S. Navy
Title *AL5/N CCS Mgr.*

9/18/92
Date

9/18/92
Date

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CHAPTER 1

INTRODUCTION

The Ada implementation described above was tested according to the Ada Validation Procedures [Pro90] against the Ada Standard [Ada83] using the current Ada Compiler Validation Capability (ACVC). This Validation Summary Report (VSR) gives an account of the testing of this Ada implementation. For any technical terms used in this report, the reader is referred to [Pro90]. A detailed description of the ACVC may be found in the current ACVC User's Guide [UG89].

1.1 USE OF THIS VALIDATION SUMMARY REPORT

Consistent with the national laws of the originating country, the Ada Certification Body may make full and free public disclosure of this report. In the United States, this is provided in accordance with the "Freedom of Information Act" (5 U.S.C. #552). The results of this validation apply only to the computers, operating systems, and compiler versions identified in this report.

The organizations represented on the signature page of this report do not represent or warrant that all statements set forth in this report are accurate and complete, or that the subject implementation has no nonconformities to the Ada Standard other than those presented. Copies of this report are available to the public from the AVF which performed this validation or from:

National Technical Information Service
5285 Port Royal Road
Springfield VA 22161

Questions regarding this report or the validation test results should be directed to the AVF which performed this validation or to:

Ada Validation Organization
Computer and Software Engineering Division
Institute for Defense Analyses
1801 North Beauregard Street
Alexandria VA 22311-1772

1.2 REFERENCES

[Ada83] Reference Manual for the Ada Programming Language,
ANSI/MIL-STD-1815A, February 1983 and ISO 8652-1987.

[Pro90] Ada Compiler Validation Procedures, Version 2.1, Ada Joint Program Office, August 1990.

[UG89] Ada Compiler Validation Capability User's Guide, 21 June 1989.

1.3 ACVC TEST CLASSES

Compliance of Ada implementations is tested by means of the ACVC. The ACVC contains a collection of test programs structured into six test classes: A, B, C, D, E, and L. The first letter of a test name identifies the class to which it belongs. Class A, C, D, and E tests are executable. Class B and class L tests are expected to produce errors at compile time and link time, respectively.

The executable tests are written in a self-checking manner and produce a PASSED, FAILED, or NOT APPLICABLE message indicating the result when they are executed. Three Ada library units, the packages REPORT and SPRT13, and the procedure CHECK_FILE are used for this purpose. The package REPORT also provides a set of identity functions used to defeat some compiler optimizations allowed by the Ada Standard that would circumvent a test objective. The package SPRT13 is used by many tests for Chapter 13 of the Ada Standard. The procedure CHECK_FILE is used to check the contents of text files written by some of the Class C tests for Chapter 14 of the Ada Standard. The operation of REPORT and CHECK_FILE is checked by a set of executable tests. If these units are not operating correctly, validation testing is discontinued. Class B tests check that a compiler detects illegal language usage. Class B tests are not executable. Each test in this class is compiled and the resulting compilation listing is examined to verify that all violations of the Ada Standard are detected. Some of the class B tests contain legal Ada code which must not be flagged illegal by the compiler. This behavior is also verified.

Class L tests check that an Ada implementation correctly detects violation of the Ada Standard involving multiple, separately compiled units. Errors are expected at link time, and execution is attempted.

In some tests of the ACVC, certain macro strings have to be replaced by implementation-specific values -- for example, the largest integer. A list of the values used for this implementation is provided in Appendix A. In addition to these anticipated test modifications, additional changes may be required to remove unforeseen conflicts between the tests and implementation-dependent characteristics. The modifications required for this implementation are described in section 2.3. For each Ada implementation, a customized test suite is produced by

the AVF. This customization consists of making the modifications described in the preceding paragraph, removing withdrawn tests (see section 2.1) and, possibly some inapplicable tests (see Section 3.2 and [UG89]).

In order to pass an ACVC an Ada implementation must process each test of the customized test suite according to the Ada Standard.

1.4 DEFINITION OF TERMS

| | |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ada Compiler | The software and any needed hardware that have to be added to a given host and target computer system to allow transformation of Ada programs into executable form and execution thereof. |
| Ada Compiler Validation Capability (ACVC) | The means for testing compliance of Ada implementations, Validation consisting of the test suite, the support programs, the ACVC Capability user's guide and the template for the validation summary (ACVC) report. |
| Ada Implementation | An Ada compiler with its host computer system and its target computer system. |
| Ada Validation Facility (AVF) | The part of the certification body which carries out the procedures required to establish the compliance of an Ada implementation. |
| Ada Validation Organization (AVO) | The part of the certification body that provides technical guidance for operations of the Ada certification system. |
| Compliance of an Ada Implementation | The ability of the implementation to pass an ACVC version. |
| Computer System | A functional unit, consisting of one or more computers and associated software, that uses common storage for all or part of a program and also for all or part of the data necessary for the execution of the program; executes user-written or user-designated programs; performs user-designated data manipulation, including arithmetic operations and logic operations; and that can execute programs that modify themselves during execution. A computer system may be a stand-alone unit or may consist of several inter-connected units. |

| | |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Conformity | Fulfillment by a product, process or service of all requirements specified. |
| Customer | An individual or corporate entity who enters into an agreement with an AVF which specifies the terms and conditions for AVF services (of any kind) to be performed. |
| Declaration of Conformance | A formal statement from a customer assuring that conformity is realized or attainable on the Ada implementation for which validation status is realized. |
| Host Computer System | A computer system where Ada source programs are transformed into executable form. |
| Inapplicable test | A test that contains one or more test objectives found to be irrelevant for the given Ada implementation. |
| Operating System | Software that controls the execution of programs and that provides services such as resource allocation, scheduling, input/output control, and data management. Usually, operating systems are predominantly software, but partial or complete hardware implementations are possible. |
| Target Computer System | A computer system where the executable form of Ada programs are executed. |
| Validated Ada Compiler | The compiler of a validated Ada implementation. |
| Validated Ada Implementation | An Ada implementation that has been validated successfully either by AVF testing or by registration [Pro90]. |
| Validation | The process of checking the conformity of an Ada compiler to the Ada programming language and of issuing a certificate for this implementation. |
| Withdrawn test | A test found to be incorrect and not used in conformity testing. A test may be incorrect because it has an invalid test objective, fails to meet its test objective, or contains erroneous or illegal use of the Ada programming language. |

CHAPTER 2

IMPLEMENTATION DEPENDENCIES

2.1 WITHDRAWN TESTS

Some tests are withdrawn by the AVO from the ACVC because they do not conform to the Ada Standard. The following 95 tests had been withdrawn by the Ada Validation Organization (AVO) at the time of validation testing. The rationale for withdrawing each test is available from either the AVO or the AVF. The publication date for this list of withdrawn tests is 91-08-02.

| | | | | | |
|---------|---------|---------|---------|---------|---------|
| E28005C | B28006C | C32203A | C34006D | C35508I | C35508J |
| C35508M | C35508N | C35702A | C35702B | B41308B | C43004A |
| C45114A | C45346A | C45612A | C45612B | C45612C | C45651A |
| C46022A | B49008A | B49008B | A74006A | C74308A | B83022B |
| B83022H | B83025B | B83025D | B83026B | C83026A | C83041A |
| B85001L | C86001F | C94021A | C97116A | C98003B | BA2011A |
| CB7001A | CB7001B | CB7004A | CC1223A | BC1226A | CC1226B |
| BC3009B | BD1B02B | BD1B06A | AD1B08A | BD2A02A | CD2A21E |
| CD2A23E | CD2A32A | CD2A41A | CD2A41E | CD2A87A | CD2B15C |
| BD3006A | BD4008A | CD4022A | CD4022D | CD4024B | CD4024C |
| CD4024D | CD4031A | CD4051D | CD5111A | CD7004C | ED7005D |
| CD7005E | AD7006A | CD7006E | AD7201A | AD7201E | CD7204B |
| AD7206A | BD8002A | BD8004C | CD9005A | CD9005B | CDA201E |
| CE2107I | CE2117A | CE2117B | CE2119B | CE2205B | CE2405A |
| CE3111C | CE3116A | CE3118A | CE3411B | CE3412B | CE3607B |
| CE3607C | CE3607D | CE3812A | CE3814A | CE3902B | |

2.2 INAPPLICABLE TESTS

A test is inapplicable if it contains test objectives which are irrelevant for a given Ada implementation. The inapplicability criteria for some tests are explained in documents issued by ISO and the AJPO known as Ada Issues and commonly referenced in the format AI-dddd. For this implementation, the following tests were inapplicable for the reasons indicated; references to Ada Issues are included as appropriate.

The following 285 tests have floating-point type declarations requiring more digits than SYSTEM.MAX_DIGITS:

| | |
|-----------------------|-----------------------|
| C24113F..Y (20 tests) | C35705F..Y (20 tests) |
| C35706F..Y (20 tests) | C35707F..Y (20 tests) |
| C35708F..Y (20 tests) | C35802F..Z (21 tests) |

| | |
|-----------------------|-----------------------|
| C45241F..Y (20 tests) | C45521F..Y (20 tests) |
| C45421F..Y (20 tests) | C45521F..Z (21 tests) |
| C45524F..Z (21 tests) | C45621F..Z (21 tests) |
| C45641F..Y (20 tests) | C46012F..Z (21 tests) |

The following 21 tests check for the predefined type `SHORT_INTEGER`; for this implementation, there is no such type:

| | | | | |
|---------|---------|---------|---------|---------|
| C35404B | B36105C | C45231B | C45304B | C45411B |
| C45412B | C45502B | C45503B | C45504B | C45504E |
| C45611B | C45613B | C45614B | C45631B | C45632B |
| B52004E | C55B07B | B55B09D | B86001V | C86006D |
| CD7101E | | | | |

C35404D, C45231D, B86001X, C86006E, and CD7101G check for a predefined integer type with a name other than `INTEGER`, `LONG_INTEGER`, or `SHORT_INTEGER`; for this implementation, there is no such type.

C35713B, C45423B, B86001T, and C86006H check for the predefined type `SHORT_FLOAT`; for this implementation, there is no such type.

C35713D and B86001Z check for a predefined floating-point type with a name other than `FLOAT`, `LONG_FLOAT`, or `SHORT_FLOAT`; for this implementation, there is no such type.

C45423A..B (2 tests), C45523A, and C45622A check that the proper exception is raised if `MACHINE_OVERFLOW` is `TRUE` and the results of various floating-point operations lie outside the range of the base type; for this implementation, `MACHINE_OVERFLOW` is `FALSE`.

C45531M..P and C45532M..P (8 tests) check fixed-point operations for types that require a `SYSTEM.MAX_MANTISSA` of 47 or greater; for this implementation, `MAX_MANTISSA` is less than 47.

B86001Y uses the name of a predefined fixed-point type other than `DURATION`; for this implementation, there is no such type.

C96005B uses values of type `DURATION`'s base type that are outside the range of type `DURATION`; for this implementation, the ranges are the same.

CD1009C checks whether a length clause can specify a non-default size for a floating-point type; this implementation does not support such sizes.

CD2A84A, CD2A84E, CD2A84I..J (2 tests), and CD2A84O use length clauses to specify non-default sizes for access types; this implementation does not support such sizes.

AE2101C and EE2201D..E (2 tests) use instantiations of package

SEQUENTIAL_IO with unconstrained array types and record types with discriminants without defaults; these instantiations are rejected by this compiler.

AE2101H, EE2401D, and EE2401G use instantiations of package DIRECT_IO with unconstrained array types and record types with discriminants without defaults; these instantiations are rejected by this compiler.

The tests listed in the following table are not applicable because the given file operations are supported for the given combination of mode and file access method.

| Test | File Operation | Mode | File Access Method |
|---------|----------------|------------|--------------------|
| CE2102E | CREATE | OUT_FILE | SEQUENTIAL_IO |
| CE2102F | CREATE | INOUT_FILE | DIRECT_IO |
| CE2102J | CREATE | OUT_FILE | DIRECT_IO |
| CE2102N | OPEN | IN_FILE | SEQUENTIAL_IO |
| CE2102O | RESET | IN_FILE | SEQUENTIAL_IO |
| CE2102P | OPEN | OUT_FILE | SEQUENTIAL_IO |
| CE2102Q | RESET | OUT_FILE | SEQUENTIAL_IO |
| CE2102R | OPEN | INOUT_FILE | DIRECT_IO |
| CE2102S | RESET | INOUT_FILE | DIRECT_IO |
| CE2102T | OPEN | IN_FILE | DIRECT_IO |
| CE2102U | RESET | IN_FILE | DIRECT_IO |
| CE2102V | OPEN | OUT_FILE | DIRECT_IO |
| CE2102W | RESET | OUT_FILE | DIRECT_IO |
| CE3102F | RESET | Any Mode | TEXT_IO |
| CE3102G | DELETE | ----- | TEXT_IO |
| CE3102I | CREATE | OUT_FILE | TEXT_IO |
| CE3102J | OPEN | IN_FILE | TEXT_IO |
| CE3102K | OPEN | OUT_FILE | TEXT_IO |

The tests listed in the following table check the given file operations for the given combination of mode and access method; this implementation does not support these operations.

| Test | File Operation | Mode | File Access Method |
|---------|----------------|---------|--------------------|
| CE2105A | CREATE | IN_FILE | SEQUENTIAL_IO |
| CE2105B | CREATE | IN_FILE | DIRECT_IO |
| CE3109A | CREATE | IN_FILE | TEXT_IO |

CE2107B..D (3 tests), CE2110B, and CE2111D check operations on sequential files when multiple internal files are associated with the same external file and one or more are open for writing; USE_ERROR is raised when this association is attempted.

CE2107E and CE2107L check operations on direct and sequential files when files of both kinds are associated with the same external file and both are open for writing; USE_ERROR is raised when this

association is attempted.

CE2107G..H (2 tests), CE2110D, and CE2111H check operations on direct files when multiple internal files are associated with the same external file and one or more are open for writing; USE_ERROR is raised when this association is attempted.

CE2203A checks that WRITE raises USE_ERROR if the capacity of an external sequential file is exceeded; this implementation cannot restrict file capacity.

CE2403A checks that WRITE raises USE_ERROR if the capacity of an external direct file is exceeded; this implementation cannot restrict file capacity.

CE3111B, CE3111D..E (2 tests), CE3114B, and CE3115A check operations on text files when multiple internal files are associated with the same external file and one or more are open for writing; USE_ERROR is raised when this association is attempted.

CE3413B checks that PAGE raises LAYOUT_ERROR when the value of the page number exceeds COUNT'LAST. For this implementation, the value of COUNT'LAST is greater than 150000, making the checking of this objective impractical.

2.3 TEST MODIFICATIONS

Modifications (see section 1.3) were required for 44 tests.

The following tests were split into two or more tests because this implementation did not report the violations of the Ada Standard in the way expected by the original tests.

| | | | | | |
|---------|---------|---------|---------|---------|---------|
| B22003A | B22004A | B23004A | B24005A | B24005B | B28003A |
| B33201C | B33202C | B33203C | B33301B | B37106A | B37301I |
| B38003A | B38003B | B38009A | B38009B | B44001A | B44004A |
| B54A01L | B55A01A | B61005A | B85008G | B85008H | B95063A |
| B97103E | BB1006B | BC1102A | BC1109A | BC1109B | BC1109C |
| BC1109D | BC1201F | BC1201G | BC1201H | BC1201I | BC1201J |
| BC1201L | BC3013A | BE2210A | BE2413A | | |

C83030C and C86007A were graded passed by Test Modification as directed by the AVO. These tests were modified by inserting "PRAGMA ELABORATE (REPORT);" before the package declarations at lines 13 and 11, respectively. Without the pragma, the packages may be elaborated prior to package Report's body, and thus the packages' calls to function REPORT.IDENT_INT at lines 14 and 13, respectively, will raise PROGRAM_ERROR.

C34005P and C34005S were graded passed by Test Modification as directed by the AVO. These tests contain expressions of the form "I - X'FIRST + Y'FIRST", where X and Y are of an array type with a lower bound of INTEGER'FIRST; this implementation recognizes that "X'FIRST + Y'FIRST" is a loop invariant and so evaluates this part of the expression separately, which raises NUMERIC_ERROR. These tests were modified by inserting parens to force a different order of evaluation (i.p., to force the subtraction to be evaluated first) at lines 187 and 262/263, respectively; those modified lines are:

[C34005P, line 187]

IF NOT EQUAL (X (I), Y ((I - X'FIRST) + Y'FIRST)) THEN

[C34005S, lines 261..4 (only 262 & 263 were modified)]

IF NOT EQUAL (X (I, J),
 Y ((I - X'FIRST) + Y'FIRST,
 (J - X'FIRST(2)) +
 Y'FIRST(2))) THEN

CHAPTER 3

PROCESSING INFORMATION

3.1 TESTING ENVIRONMENT

The Ada implementation tested in this validation effort is described adequately by the information given in the initial pages of this report.

For a point of contact for technical information about this Ada implementation system, see:

Mr. Christopher T. Geyer
Fleet Combat Directions Systems Support Activity
Code 81, Room 301D
200 Catalina Blvd.
San Diego, California 92147
619-553-9447

For a point of contact for sales information about this Ada implementation system, see:

NOT APPLICABLE FOR THIS IMPLEMENTATION

Testing of this Ada implementation was conducted at the customer's site by a validation team from the AVF.

3.2 SUMMARY OF TEST RESULTS

An Ada Implementation passes a given ACVC version if it processes each test of the customized test suite in accordance with the Ada Programming Language Standard, whether the test is applicable or inapplicable; otherwise, the Ada Implementation fails the ACVC [Pro90].

For all processed tests (inapplicable and applicable), a result was obtained that conforms to the Ada Programming Language Standard.

The list of items below gives the number of ACVC tests in various categories. All tests were processed, except those that were withdrawn because of test errors (item b; see section 2.1), those that require a floating-point precision that exceeds the implementation's maximum precision (item e; see section 2.2), and those that depend on the support of a file system -- if none is supported (item d). All tests passed, except those that are listed in sections 2.1 and 2.2 (counted in items b and f, below).

| | | |
|-------------------------------------------------|------|---------|
| a) Total Number of Applicable Tests | 3692 | |
| b) Total Number of Withdrawn Tests | 95 | |
| c) Processed Inapplicable Tests | 383 | |
| d) Non-Processed I/O Tests | 0 | |
| e) Non-Processed Floating-Point Precision Tests | 0 | |
| f) Total Number of Inapplicable Tests | 383 | (c+d+e) |
| g) Total Number of Tests for ACVC 1.11 | 4170 | (a+b+f) |

When this implementation was tested, the tests listed in section 2.1 had been withdrawn because of test errors.

3.3 TEST EXECUTION

A magnetic tape containing the customized test suite (see section 1.3) was taken on-site by the validation team for processing. The contents of the magnetic tape were loaded directly onto the host computer.

After the test files were loaded onto the host computer, the full set of tests was processed by the Ada implementation.

The tests were compiled, linked, and executed on the host/ target computer system.

Testing was performed using command scripts provided by the customer and reviewed by the validation team. See Appendix B for a complete listing of the processing options for this implementation. It also indicates the default options. The options invoked explicitly for validation testing during this test were:

```
/SUMMARY /NO_TRACE_BACK /OPTIMIZE /SOURCE
/OUT=<filename>
```

The options invoked by default for validation testing during this test were:

```
/NO_MACHINE_CODE /NO_ATTRIBUTE /NO_CROSS_REFERENCE
/NO_DIAGNOSTICS /NO_NOTES /PRIVATE /LIST
/CONTAINER_GENERATION /CODE_ON_WARNING /NO_MEASURE /DEBUG
/CHECKS
```

Test output, compiler and linker listings, and job logs were captured on magnetic tape and archived at the AVF. Selected listings examined on-site by the validation team were also archived.

APPENDIX A

MACRO PARAMETERS

This appendix contains the macro parameters used for customizing the ACVC. The meaning and purpose of these parameters are explained in [UG89]. The parameter values are presented in two tables. The first table lists the values that are defined in terms of the maximum input-line length, which is | the value for \$MAX_IN_LEN--also listed here. These values are expressed here as Ada string aggregates, where "V" represents the maximum input-line length.

| Macro Parameter | Macro Value |
|---------------------------------------------|---------------------------------------------|
| <hr style="border-top: 1px dashed black;"/> | |
| \$MAX_IN_LEN | 120 |
| \$BIG_ID1 | (1..V-1 => 'A', V => '1') |
| \$BIG_ID2 | (1..V-1 => 'A', V => '2') |
| \$BIG_ID3 | (1..V/2 => 'A') & '3' & (1..V-1-V/2 => 'A') |
| \$BIG_ID4 | (1..V/2 => 'A') & '4' & (1..V-1-V/2 => 'A') |
| \$BIG_INT_LIT | (1..V-3 => '0') & "298" |
| \$BIG_REAL_LIT | (1..V-5 => '0') & "690.0" |
| \$BIG_STRING1 | '"' & (1..V/2 => 'A') & '"' |
| \$BIG_STRING2 | '"' & (1..V-1-V/2 => 'A') & '1' & '"' |
| \$BLANKS | (1..V-20 => ' ') |
| \$MAX_LEN_INT_BASED_LITERAL | "2:" & (1..V-5 => '0') & "11:" |
| \$MAX_LEN_REAL_BASED_LITERAL | "16:" & (1..V-7 => '0') & "F.E:" |
| \$MAX_STRING_LITERAL | '"' & (1..V-2 => 'A') & '"' |

The following table contains the values for the remaining macro parameters.

| Macro Parameter | Macro Value |
|---------------------------------------|-------------------------------------------------|
| \$ACC_SIZE | 32 |
| \$ALIGNMENT | 4 |
| \$COUNT_LAST | 2_147_483_647 |
| \$DEFAULT_MEM_SIZE | 1073741823 |
| \$DEFAULT_STOR_UNIT | 8 |
| \$DEFAULT_SYS_NAME | ADAVAX |
| \$DELTA_DOC | 0.000_000_000_465_661_287_307_ 739_257_812_5 |
| \$ENTRY_ADDRESS | 16#40# |
| \$ENTRY_ADDRESS1 | 16#80# |
| \$ENTRY_ADDRESS2 | 16#100# |
| \$FIELD_LAST | 32_767 |
| \$FILE_TERMINATOR | ' ' |
| \$FIXED_NAME | NO_SUCH_TYPE_AVAILABLE |
| \$FLOAT_NAME | NO_SUCH_TYPE_AVAILABLE |
| \$FORM_STRING | "" |
| \$FORM_STRING2 | "CANNOT_RESTRICT_FILE_CAPACITY" |
| \$GREATER_THAN_DURATION | 75_000.0 |
| \$GREATER_THAN_DURATION_BASE_LAST | 131_073.0 |
| \$GREATER_THAN_FLOAT_BASE_LAST | 1.80141E+38 |
| \$GREATER_THAN_FLOAT_SAFE_LARGE | 1.0E308 |
| \$GREATER_THAN_SHORT_FLOAT_SAFE_LARGE | 1.0E308 |
| \$HIGH_PRIORITY | 15 |

\$ILLEGAL_EXTERNAL_FILE_NAME1 BADCHAR^@.-!
 \$ILLEGAL_EXTERNAL_FILE_NAME2
 MUCH_TOO_LONG_NAME_FOR_A_FILE_UNDER_VMS_SO_THE_SO_THERE
 \$INAPPROPRIATE_LINE_LENGTH 256
 \$INAPPROPRIATE_PAGE_LENGTH -1
 \$INCLUDE_PRAGMA1 PRAGMA INCLUDE ("A28006D1.TST")
 \$INCLUDE_PRAGMA2 PRAGMA INCLUDE ("B28006F1.TST")
 \$INTEGER_FIRST -32768
 \$INTEGER_LAST 32767
 \$INTEGER_LAST_PLUS_1 32768
 \$INTERFACE_LANGUAGE ASMVAX_JSB
 \$LESS_THAN_DURATION -75000.0
 \$LESS_THAN_DURATION_BASE_FIRST -131073.0
 \$LINE_TERMINATOR ' '
 \$LOW_PRIORITY 1
 \$MACHINE_CODE_STATEMENT BYTE_OP_CODE' (OP=>NOP);
 \$MACHINE_CODE_TYPE BYTE
 \$MANTISSA_DOC 31
 \$MAX_DIGITS 9
 \$MAX_INT 2147483647
 \$MAX_INT_PLUS_1 2147483648
 \$MIN_INT -2147483648
 \$NAME NO_SUCH_TYPE_AVAILABLE
 \$NAME_LIST ADAVAX, ADA_L, ADA_M
 \$NAME_SPECIFICATION1
 ALSN\$TEST:[ALSN_TESTS.ACVC.TESTACVCVAX.RUNNING]X2120A.;1

\$NAME_SPECIFICATION2
 ALSN\$TEST:[ALSN_TESTS.ACVC.TESTACVCVAX.RUNNING]X2120B.;1

\$NAME_SPECIFICATION3
 ALSN\$TEST:[ALSN_TESTS.ACVC.TESTACVCVAAX.RUNNING]X3119A.;1

\$NEG_BASED_INT 16#FFFFFFFFE#

\$NEW_MEM_SIZE 1073741823

\$NEW_STOR_UNIT 8

\$NEW_SYS_NAME ADA_L

\$PAGE_TERMINATOR ASCII.FF

\$RECORD_DEFINITION RECORD LWORD_1:LONG_WORD;
 LWORD_2:LONG_WORD; END RECORD;

\$RECORD_NAME QUADWORD

\$TASK_SIZE 32

\$TASK_STORAGE_SIZE 1024

\$TICK 0.01

\$VARIABLE_ADDRESS 16#0020#

\$VARIABLE_ADDRESS1 16#0024#

\$VARIABLE_ADDRESS2 16#0028#

\$YOUR_PRAGMA TITLE ("THIS IS AN ALS/N ACVC
 TITLE")

APPENDIX B

COMPILATION SYSTEM OPTIONS

The compiler options of this Ada implementation, as described in this Appendix, are provided by the customer. Unless specifically noted otherwise, references in this appendix are to compiler documentation and not to this report.

Section 9
Compiler Options

| Option | Function |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MEASURE | Generates code to monitor execution frequency at the subprogram level for the current unit. Default: NO_MEASURE |
| NO_CHECKS | NO_CHECKS suppresses all run-time error checking. CHECKS provides run-time error checking. Default: CHECKS |
| NO_CODE_ON_WARNING | NO_CODE_ON_WARNING means no code is generated when there is a diagnostic of severity WARNING or higher. CODE_ON_WARNING generates code only if there are no diagnostics of a severity higher than WARNING. Default: CODE_ON_WARNING |
| NO_CONTAINER_GENERATION | NO_CONTAINER_GENERATION means that no container is produced even if there are no diagnostics. CONTAINER_GENERATION produces a container if diagnostic severity permits. Default: CONTAINER_GENERATION |

Table 9-1a - Special Processing Options

| Option | Function |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NO_DEBUG | <p>If NO_DEBUG is specified, only that information needed to link, export and execute the current unit is included in the compiler output.</p> <p>With the DEBUG option in effect, internal representations and additional symbolic information are stored in the container. Default: DEBUG</p> |
| NO_TRACE_BACK | <p>Disables the location of source exceptions that are not handled by built-in exception handlers. Default: TRACE_BACK</p> |
| OPTIMIZE | <p>Enables global optimizations in accordance with the optimization pragmas specified in the source program. If the pragma OPTIMIZE is not included, the optimizations emphasize TIME over SPACE. When NO_OPTIMIZE is in effect, no global optimizations are performed, regardless of the pragmas specified. Default: NO_OPTIMIZE</p> |

Table 9-1b - Special Processing Options (Continued)

| Option | Function |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ATTRIBUTE | Produces a Symbol Attribute Listing. (Produces an attribute cross-reference listing when both ATTRIBUTE and CROSS_REFERENCE are specified.) Default: NO_ATTRIBUTE |
| CROSS_REFERENCE | Produces a Cross-Reference Listing. (Produces an attribute cross-reference listing when both ATTRIBUTE and CROSS_REFERENCE are specified.) Default: NO_CROSS_REFERENCE |
| DIAGNOSTICS | Produces a Diagnostic Summary Listing. Default: NO_DIAGNOSTICS |
| MACHINE_CODE | Produces a machine code listing if code is generated. Code is generated when CONTAINER GENERATION option is in effect and (1) there are no diagnostics of severity ERROR, SYSTEM or FATAL, and/or (2) NO_CODE_ON_WARNING option is in effect and there are no diagnostics of severity higher than NOTE. Default: NO_MACHINE_CODE |
| NOTES | Includes diagnostics of NOTE severity level in the Source Listing. Default: NO_NOTES |
| NO_PRIVATE | Excludes listing of Ada statements in private part if a Source Listing is produced. Default: PRIVATE |
| SOURCE | Produce listing of Ada source statements. Default: NO_SOURCE |
| SUMMARY | Produce a Summary Listing; always produced when there are errors in the compilation. Default: NO_SUMMARY |

Table 9-2 - Listing Control Options

| Option | Function |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MSG | Sends error messages and the Diagnostic Summary Listing to the file specified. The default is to send error messages and the Diagnostic Summary Listing to Message Output (usually the terminal). |
| OUT | Sends all selected listings to the single file specified. The default is to send listings to Standard Output (usually the terminal). |

Table 9-3 - Control_Part (Redirection) Options

LINKER OPTIONS

The linker options of this Ada implementation, as described in this Appendix, are provided by the customer. Unless specifically noted otherwise, references in this appendix are to linker documentation and not to this report.

Section 11
Linker Options

| Option | Function |
|-----------|-------------------------------------------------------------------------------------------------------------------|
| DEBUG | Produces a linked container to be debugged. Default: NO_DEBUG. |
| MEASURE | Produces a linked container to be analyzed. Default: NO_MEASURE |
| NO_SEARCH | Limits the contents of the linked container to those units explicitly specified in the UNITLIST. Default: SEARCH. |
| PARTIAL | Produces an incomplete linked container with unresolved references. Default: NO_PARTIAL. |

Table 11-1 - LNKVAX Linker Special Processing Options

| Option | Function |
|-----------|------------------------------------------------------------------------------------|
| no option | Linker Summary listing, always produced unless diagnostics prevent its generation. |
| ELAB_LIST | Generates an elaboration order listing. Default: NO_ELAB_LIST. |
| SYMBOLS | Produces a Linker symbols listing. Default: NO_SYMBOLS. |
| UNITS | Produces a Linker units listing. Default: NO_UNITS. |

Table 11-2 - LNKVAX Linker Listing Options

| Option | Function |
|--------|--------------------------------------------------------------------------------------------------------------------------------------|
| MSG | Sends error messages to the file specified. The default is to send error messages to Message Output (usually the terminal). |
| OUT | Sends all selected listings to the single file specified. The default is to send listings to Standard Output (usually the terminal). |

Table 11-3 - Control_Part (Redirection) Options

Section 12
Exporter Options

| Option | Function |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACCOUNTING | Causes the amount of CPU time and wall clock time used by the program to be reported at program termination to message output. Default: NO_ACCOUNTING |
| DEBUG | Produces a load module that can be debugged by the ALS/N Symbolic Debugger. Default: NO_DEBUG |
| DEBUG_SYMBOLS | Produces a file of external symbols suitable for input to the VAX/VMS Debugger. Default: NO_DEBUG_SYMBOLS |
| MEASURE | Produces a load module that includes the invocation of frequency and statistical analyzer. Default: NO_MEASURE |

Table 12-1 - Special Processing Options

| Option | Function |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------|
| no option | Exporter Summary Listing is always produced unless diagnostics prevent its generation. |
| MAP | Produces a program sections map listing that summarizes the executable image. Default: NO_MAP |
| SYMBOLS | Produces a list of external symbol descriptor information for external definitions contained in the object module. Default: NO_SYMBOLS |

Table 12-2 - Listing Options

| Option | Function |
|--------|--------------------------------------------------------------------------------------------------------------------------------------|
| MSG | Sends error messages to the file specified. The default is to send error messages to Message Output (usually the terminal). |
| OUT | Sends all selected listings to the single file specified. The default is to send listings to Standard Output (usually the terminal). |

Table 12-3 - Control_Part (Redirection) Options

APPENDIX C

APPENDIX F OF THE Ada STANDARD

The only allowed implementation dependencies correspond to implementation-dependent pragmas, to certain machine-dependent conventions as mentioned in Chapter 13 of the Ada Standard, and to certain allowed restrictions on representation clauses. The implementation-dependent characteristics of this Ada implementation, as described in this Appendix, are provided by the customer. Unless specifically noted otherwise, references in this Appendix are to compiler documentation and not to this report. Implementation-specific portions of the package STANDARD, which are not a part of Appendix F, are:

package STANDARD is

```
type INTEGER is range -32_768 .. 32_767;
type LONG_INTEGER is range -2_147_483_648 .. 2_147_483_647;
type FLOAT is digits 6 range
  -(2#0.1111_1111_1111_1111_1111_1#E127) ..
  (2#0.1111_1111_1111_1111_1111_1#E127);
type LONG_FLOAT is digits 9 range
  -(2#0.1111_1111_1111_1111_1111_1111_1111_111#E127) ..
  (2#0.1111_1111_1111_1111_1111_1111_1111_111#E127);
type DURATION is delta 2.0 ** (-14) range
  -131_072.0 .. 131_072.0 - 2.0 ** (-14);
```

end STANDARD;

Appendix F

The Ada Language for the VAX Target

The source language accepted by the compiler is Ada, as described in the Military Standard, Ada Programming Language, ANSI/MIL-STD-1815A-1983, 17 February 1983 ("Ada Language Reference Manual").

The Ada definition permits certain implementation dependencies. Each Ada implementation is required to supply a complete description of its dependencies, to be thought of as Appendix F to the Ada Language Reference Manual. This section is that description for the VAX/VMS target.

F.1 Options

There are several compiler options provided by all ALS/N Compilers that directly affect the pragmas defined in the Ada Language Reference Manual. These compiler options currently include the CHECKS and OPTIMIZE options that affect the SUPPRESS and OPTIMIZE pragmas, respectively. A complete list of ALS/N Compiler options can be found in Section 9.

The CHECKS option enables all run-time error checking for the source file being compiled, which can contain one or more compilation units. This allows the SUPPRESS pragma to be used in suppressing the run-time checks discussed in the Ada Language Reference Manual, but note that the SUPPRESS pragmas must be applied to each compilation unit. The NO CHECKS option disables all run-time error checking for all compilation units within the source file and is equivalent to SUPPRESSing all run-time checks within every compilation unit.

The OPTIMIZE option enables all compile-time optimizations for the source file being compiled, which can contain one or more compilation units. This allows the OPTIMIZE pragma to request either TIME-oriented or SPACE-oriented optimizations be performed, but note that the OPTIMIZE pragma must be applied to each compilation unit. If the OPTIMIZE pragma is not present, the ALS/N Compiler's Global Optimizer tends to optimize for TIME over SPACE. The NO OPTIMIZE option disables all compile-time optimizations for all compilation units within the source file regardless of whether or not the OPTIMIZE pragma is present.

F.2 Pragmas

Both implementation-defined and Ada language-defined pragmas are provided by all ALS/N Compilers. The syntax defined in the Ada Language Reference Manual allows pragmas as the only element in a compilation, before a compilation unit, at defined places within a compilation unit, or following a compilation unit. The ALS/N Compilers associates pragmas with compilation units as follows:

- a. If a pragma appears before any compilation unit in a compilation, it will affect all following compilation units, as specified below, and in the Ada Language Reference Manual.
- b. If a pragma appears inside a compilation unit, it will be associated with that compilation unit, and in listings associated with that compilation unit as described in the Ada Language Reference Manual, or in this document.
- c. If a pragma follows a compilation unit, it will be associated with the preceding compilation unit, and the effects of the pragma will be found in the container of that compilation unit, and in listings associated with that container.

The pragmas `MEMORY_SIZE`, `STORAGE_UNIT`, and `SYSTEM_NAME` are described in Section 13.7 of the Ada Language Reference Manual. They may appear only at the start of the first compilation when creating a new program library. In the ALS/N, however, since program libraries are created by the Program Library Manager and not by the compiler, the use of these pragmas is obviated. If they appear anywhere, a diagnostic of severity level `WARNING` is generated.

F.2.1 Language-defined Pragmas

The following notes specify the language-required definitions of the predefined pragmas. Unmentioned language-defined pragmas are implemented as defined by the Ada Language Reference Manual.

`pragma INLINE (subprogram_name);`

There are three instances in which the `INLINE` pragma is ignored. Each of these cases produces a warning message that states the `INLINE` did not occur.

- a. If a call to an `INLINE` subprogram is compiled before the actual body of the subprogram has been compiled, a routine call is made instead.
- b. If the compilation unit containing the `INLINE` subprogram depends on the compilation unit of its caller, a routine call is made instead.
- c. If an immediately recursive subprogram call is made within the body of the `INLINE` subprogram, the `pragma INLINE` is ignored entirely.

`pragma INTERFACE (language_name, subprogram_name);`

Two `language_names` will be recognized and implemented:

`ASMVAX_JSB`, and `ASMVAX_CALLS`.

The `language_name` `ASMVAX_JSB` indicates that a subprogram written in the VAX/VMS assembler language will be called with a `JSB` instruction and the parameters passed in registers. The `language_name` `ASMVAX_CALLS` will provide an interface to a VAX assembler language subprogram via the `CALLS` instruction, with the parameters passed on the stack, with the same parameter passing conventions used for calling Ada subprograms.

The user must ensure that an assembly-language body container for this specification exists in the program library before linking.

`pragma MEMORY_SIZE;`

This pragma is ignored and a WARNING diagnostic is issued.

`pragma OPTIMIZE (arg);`

The argument is either TIME or SPACE. If TIME is specified, the optimizer concentrates on optimizing code execution time. If SPACE is specified, the optimizer concentrates on optimizing code size. The default is If the OPTIMIZE option is enabled and pragma OPTIMIZE is not present, global optimization is still performed with the default argument, SPACE. Program units containing OPTIMIZE pragmas and compiled with the OPTIMIZE option may be linked with program units containing OPTIMIZE pragmas and compiled with the NO_OPTIMIZE option; but only those program units compiled with the OPTIMIZE option will have global optimization support.

`pragma PRIORITY (arg)1;`

The argument is an integer static expression in the range 0..15, where 0 is the lowest use-specifiable task priority and 15 is the highest. If the value of the argument is out of range, the pragma will have no effect other than to generate a WARNING diagnostic. A value of zero will be used if priority is not defined. The pragma will have no effect when not specified in a task (type) specification or the outermost declarative part of a subprogram. If the pragma appears in the declarative part of a subprogram, it will have no effect unless that subprogram is designated as the main subprogram at link time.

`pragma STORAGE_SIZE;`

This pragma is ignored and a WARNING diagnostic is issued.

`pragma SUPPRESS (arg[,arg]);`

Pragmas to suppress `OVERFLOW_CHECK` will have no effect for operations of integer types.

A `SUPPRESS` pragma will have effect only within the compilation unit in which it appears, except that a `SUPPRESS` of `ELABORATION_CHECK` applied at the declaration of a subprogram or task unit will apply to all calls or activations.

`pragma SYSTEM_NAME;`

This pragma is ignored and a WARNING diagnostic is issued.

F.2.2 Implementation-defined Pragmas

The following is the only implementation-defined pragma:

```
pragma TITLE (arg);
```

This is a listing control pragma. It takes a single argument of type string. The string specified will appear on the second line of each page of the source listing produced for the compilation unit within which it appears. The pragma should be the first lexical unit to appear within a compilation unit (excluding comments). If it is not, a warning message is issued.

F.2.3 Scope of Pragmas

The scope of pragmas is as described in the P'a Language Reference Manual except as noted below:

MEMORY_SIZE - No scope, but a WARNING diagnostic is generated.

PAGE - No scope.

STORAGE_SIZE - No scope, but a WARNING diagnostic is generated.

SYSTEM_NAME - No scope, but a WARNING diagnostic is generated.

TITLE - The compilation unit within which the pragma occurs.

F.3 Attributes

There is one implementation-defined attribute in addition to the predefined attributes found in Appendix A of the Ada Language Reference Manual.

X'DISP

A value of type `UNIVERSAL_INTEGER` that corresponds to the displacement that is used to address the first storage unit occupied by a data object `X` at a static offset within an implemented activation record.

This attribute differs from the `ADDRESS` attribute in that `ADDRESS` supplies the absolute address while `DISP` supplies the displacement relative to some base value (such as a stack frame pointer). It is the user's responsibility to determine the base value relevant to the attribute.

The following notes augment the language-required definitions of the predefined attributes found in Appendix A of the Ada Language Reference Manual.

- | | |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>T'MACHINE_EMAX</code> | is 127. |
| <code>T'MACHINE_EMIN</code> | is -127. |
| <code>T'MACHINE_MANTISSA</code> | if the size of the base type <code>T</code> is 32, <code>MACHINE_MANTISSA</code> is 24. if the size of the base type <code>T</code> is 64, <code>MACHINE_MANTISSA</code> is 56. |
| <code>T'MACHINE_OVERFLOW</code> | is true. |
| <code>T'MACHINE_RADIX</code> | is 2. |
| • <code>T'MACHINE_ROUNDS</code> | is false. |

F.4 Predefined Language Environment

The predefined Ada language environment consists of the packages `STANDARD` and `SYSTEM` described below.

F.4.1 Package STANDARD

The Package STANDARD contains the following definitions in addition to those specified in Appendix C of the Ada Language Reference Manual:

```
TYPE boolean IS (false,true);
FOR boolean'SIZE USE 1;

TYPE integer IS RANGE -32_768 .. 32_767;
TYPE long_integer IS RANGE -2_147_483_648 .. 2_147_483_647;

TYPE float IS DIGITS 6 RANGE
  - (2#0.1111_1111_1111_1111_1111_1#E127) ..
    (2#0.1111_1111_1111_1111_1111_1#E127);

TYPE long_float IS DIGITS 9 RANGE
  - (2#0.1111_1111_1111_1111_1111_1111_1111_111#E127) ..
    (2#0.1111_1111_1111_1111_1111_1111_1111_111#E127);

SUBTYPE natural IS integer RANGE 0 .. integer'LAST;
SUBTYPE positive IS integer RANGE 1 .. integer'LAST;

-- Additions to predefined subtypes:

SUBTYPE long_natural IS long_integer
  RANGE 0 .. long_integer'LAST;
SUBTYPE long_positive IS long_integer
  RANGE 1 .. long_integer'LAST;

FOR character'SIZE USE 8;
TYPE string IS ARRAY (positive RANGE <>) OF character;
PRAGMA PACK(string);

TYPE duration IS DELTA 2.0 ** (-14)
  RANGE -131_072.0 .. 131_072.0
```

F.4.2 Package SYSTEM

Within the various implementations, no corresponding package body is required for the package SYSTEM. The package SYSTEM is as follows:

```

type ADDRESS is new LONG_INTEGER;
type NAME     is (AdaVAX, Ada_L, Ada_M);
SYSTEM_NAME   : constant NAME := AdaVAX;
STORAGE_UNIT  : constant := 8;
MEMORY_SIZE   : constant := 2**30 - 1;

-- System-Dependent Named Numbers:

MIN_INT       : constant := -(2**31);
MAX_INT       : constant := (2**31)-1;
MAX_DIGITS    : constant := 9;
MAX_MANTISSA  : constant := 31;
FINE_DELTA    : constant := 2.0**(-31);
TICK          : constant := 0.01;

-- Other System-Dependent Declarations

subtype PRIORITY is INTEGER range 1..15;

--
-- The following exceptions are provided as a "convention"
-- whereby the Ada program can be compiled with all implicit
-- checks suppressed (i.e., pragma SUPPRESS or equivalent),
-- explicit checks included as necessary, the appropriate
-- exception raised when required, and then the exception is
-- either handled or the Ada program terminates.
--
ACCESS_CHECK           : exception;
DISCRIMINANT_CHECK     : exception;
INDEX_CHECK            : exception;
LENGTH_CHECK           : exception;
RANGE_CHECK            : exception;
DIVISION_CHECK         : exception;
OVERFLOW_CHECK         : exception;
ELABORATION_CHECK      : exception;
STORAGE_CHECK          : exception;

--
-- The following exceptions provide for (1) Ada programs that
-- contain unresolved subprogram calls and (2) VAX/VMS
-- system-level errors.
--
UNRESOLVED_REFERENCE  : exception;
SYSTEM_ERROR          : exception;

```


F.5 Character Set

Ada compilations may be expressed using the following characters, in addition to the basic character set:

lower case letters:

a b c d e f g h i j k l m n o p q r s t u v w x y z

special characters:

! \$ % ? @ [] ^ _ { } ~

The following transliterations are permitted (see Paragraph 2.10 of the Ada Language Reference Manual):

- a. Exclamation mark for vertical bar;
- b. Colon for sharp; and
- c. Percent for double_quote.

F.6 Declaration and Representation Restrictions

Declarations are described in Chapter 3 of the Ada Language Reference Manual. Representation specifications are described in Chapter 13 and discussed here.

In the following specifications, the capitalized word SIZE indicates the number of bits used to represent an object of the type under discussion. The upper case symbols D, L, and R correspond to those discussed in Section 3.5.9 of the Ada Language Reference Manual.

F.6.1 Integer Types

Integer types are specified with constraints of the form:

RANGE L..R

where:

$R \leq \text{SYSTEM.MAX_INT}$ & $L \geq \text{SYSTEM.MIN_INT}$

For an integer type, length specifications of the form:

FOR t'SIZE USE n;

may specify integer values n such that n is in 2..32,

$R \leq 2^{(n-1)}-1$ & $L \geq -2^{(n-1)}$;

or else such that

$R \leq (2^N)-1$ & $L \geq 0$

and N is in 1..31.

For a stand-alone object of integer type, a default SIZE of 16 is used when:

$R \leq 2^{15}-1$ & $L \geq -2^{15}$

Otherwise a SIZE of 32 is used.

For components of integer types within packed composite objects, the smaller of the default stand-alone SIZE or the SIZE from a length specification will be used.

F.6.2 Floating Types

Floating types are specified with constraints of the form:

DIGITS D

where D is an integer value in 1 through 9.

For floating point types, length specifications of the form:

FOR t'SIZE USE n;

are permitted only when the integer values N = 32 when D ≤ 6,
or N = 64 when D ≤ 9.

When no length specification is provided, a size of 32 is used
when D ≤ 6; 64 when D is 7 through 9.

F.6.3 Fixed Types

Fixed types are specified with constraints of the form:

delta D range L..R

where:

$$\frac{\max(\text{abs}(R), \text{abs}(L))}{\text{actual_delta}} < 2^{31-1}$$

The actual delta defaults to the largest integral power of 2
less than or equal to the specified delta D. (This implies
that fixed point values are stored right-aligned.)

For fixed point types, length specifications of the form:

for T'SIZE use N;

are permitted only when N in 1 .. 32, if:

$$R - \text{actual_delta} \leq 2^{(N-1)-1} * \text{actual_delta}, \text{ and}$$

$$L + \text{actual_delta} \geq -2^{(N-1)} * \text{actual_delta}$$

or

$$R - \text{actual_delta} \leq 2^{(N)-1} * \text{actual_delta}, \text{ and}$$
$$L \geq 0$$

For stand-alone objects of fixed point type, a default size of 32 is used. For components of fixed point types within packed composite objects, the size from the length specification will be used.

Specifications of the form:

for T'SMALL use X;

are permitted for any value of X, such that $X \leq D$. X must be specified either as a base 2 value or as a base 10 value. Note that when X is specified as other than a power of 2, The 'SMALL value of a fixed point type may be set to any value less than D, are permitted for any value of X, such that $X \leq D$. X must be specified either as a base 2 value or as a base 10 value. If X is a power of 2, then X will be used for the actual delta; if X is a power of 10, then an actual delta will be chosen which is one eighth ($1/8$) of the largest integral power of 2 less than or equal to X; otherwise, the largest integral power of two less than X will be used as the actual delta. All stand-alone fixed point objects have a size of 32. If a 'SIZE specification is given, fixed point components of packed composites will have the size specified.

F.6.4 Enumeration Types

In the absence of a representation specification for an enumeration type T, the internal representation of T'FIRST = 0. The default SIZE for a stand-alone object of enumeration type T will be the smallest of the values 8, 16, or 32, such that the internal representation of T'FIRST and T'LAST both falls within the range:

$$-2^{(T'SIZE-1)} \dots 2^{(T'SIZE-1)}-1.$$

For enumeration types, length specification of the form:

for T'SIZE use N;

and/or enumeration representations of the form:

for T use <aggregate>;

are permitted for N in 2..32, provided that the internal representations and the SIZE conform to the relationship specified above.

Or else for N in 1..31, is supported for enumeration types and provides an internal representation of:

$$T'FIRST \geq 0 \dots T'LAST \leq 2^{(T'SIZE)}-1.$$

For components of enumeration types within packed composite objects, the smaller of the default stand-alone SIZE, or the SIZE from a length specification will be used.

Enumeration representation on types derived from the predefined type BOOLEAN will not be accepted, but length specifications will be accepted.

F.6.5 Access Types

For access type, T, length specifications of the form:

for T'SIZE use N;

will not affect the run-time implementation of T, therefore N = 32 is the only value permitted for SIZE, which is the value returned by the attribute.

For collection size specifications of the form:

for T'STORAGE_SIZE use N;

any value of N is permitted (and that value will be returned by the attribute call). The collection size specification will affect the implementation of T and its collection at run-time by limiting the number of objects for type T that can be allocated.

F.6.6 Arrays and Records

For arrays and records, length specifications of the form:

for T'SIZE use N;

may cause arrays and records to be packed, if required, to accommodate the length specification. If the SIZE specified is not large enough to contain all possible values of the components, a diagnostic message of severity ERROR is issued.

The PACK pragma may be used to minimize wasted space, if any, between components of arrays and records. The pragma causes the type representation to be chosen such that storage space requirements are minimized at the possible expense of data access time and code space.

For records, a component clause of the form:

at N [range i..j] .

specifies the allocation of components in a record. Bits are numbered 0..7 from the right and bit 8 starts at the right of the next higher-number byte. Each location specification must allow at least X bits of range, where X is large enough to hold any value of the subtype of the component being allocated. Otherwise, a diagnostic message of severity ERROR is generated.

For records, an alignment clause of the form:

at mod N

specify alignments of N bytes for 1 byte, 2 bytes (VAX "word"), and 4 bytes (VAX "long_word").

If it is determinable at compilation time that the SIZE of a record or array type or subtype maybe outside the range of STANDARD.LONG_INTEGER, a diagnostic message of severity WARNING is generated. Declaration of an object of such a type or subtype would raise NUMERIC_ERROR when elaborated. Note that a discriminant record or array may never raise the NUMERIC_ERROR when elaborated based on the actual discriminant provided.

F.6.7 Other Length Specifications

Length Specifications are described in Section 13.2 of the Ada Language Reference Manual.

A length specification for a task type T, of the form:

for T'SIZE use N;

specifies the number of bits to be allocated for objects of the task type T. For the VAX/VMS target, N must be defined as 32.

F.7 System Names

Refer to Section 13.7 of the Ada Language Reference Manual for a discussion of package SYSTEM.

The available system names are "AdaVAX", "Ada_L", and "Ada_M"; the system name is chosen based on the targets supported, but it can not be changed. In the case of VAX/VMS, the system name is "AdaVAX".

F.8 Address Clauses

Refer to Section 13.5 of the Ada Language Reference Manual for a discussion of Address Clauses. Address clauses for objects and code are allowed by the VAX/VMS target, but they have no effect beyond changing the value returned by the 'ADDRESS attribute call.

The Run-Time Support Library (RSL) for the VAX/VMS target does not handle hardware interrupts. All hardware interrupts are handled by the VAX/VMS operating system. However, the VAX/VMS target uses asynchronous system traps (ASTs) in a manner similar to interrupt entries.

F.9 Unchecked Conversions

Refer to Section 13.10.2 of the Ada Language Reference Manual for a description of UNCHECKED_CONVERSION.

A program is erroneous if it performs UNCHECKED_CONVERSION when the source and target have different sizes.

F.10 Restrictions on the Main (Sub)Program

Refer to Section 10.1 of the Ada Language Reference Manual for a discussion of the main (sub)program. The subprogram designated as the main (sub)program cannot have parameters. The designation as the main (sub)program of a subprogram whose specification contains a formal_part results in a diagnostic of severity ERROR at link time.

The main (sub)program can be a function, but the return value will not be available upon completion of the main (sub)program's execution. The main (sub)program may not be an imported subprogram.

F.11 Input/Output

Refer to Chapter 14 of the Ada Language Reference Manual for a description of Ada Input/Output (I/O).

The RSL I/O subsystem provides the following packages to the user: TEXT_IO, SEQUENTIAL_IO, DIRECT_IO, and LOW_LEVEL_IO. These packages execute in the context of the an individual Ada task making the I/O request. Consequently, all of the code that process an I/O request on behalf of the Ada task executes sequentially. The package IO_EXCEPTIONS defines all of the exceptions needed by the packages TEXT_IO, SEQUENTIAL_IO, and DIRECT_IO. The specification of this package is given in Section 14.5 of the Ada LRM. This package is visible to all of the constituent packages of the RSL I/O subsystem so that appropriate exception handlers can be inserted.

High-level I/O in AdaVAX is performed solely on external files. No allowance is provided in the RSL I/O subsystem for memory resident files (i.e., files which do not reside on a peripheral device). This is true even in the case of temporary files. With the external files residing on peripheral devices, only the various VAX/VMS quotas restricts the number of files that may be open on an individual peripheral device.

Section 14.1 of the Ada LRM states that all I/O operations are expressed as operations on objects of some file type, rather than in terms of an external file. File objects are implemented in AdaVAX as access objects that point to a data structure call the File Control Block (FCB). This FCB is defined internally to each high-level I/O package; its purpose is to represent an external file. The FCB contains all of the I/O-specific information about an external file that is needed by the high-level packages to accomplish the requested I/O operation.

F.11.1 Naming External Files

The naming conventions for external files in AdaVAX are of particular importance to the user. An external file name for Ada I/O can be any valid path name (e.g., disk:[directories]filename.ext) in the VAX/VMS environment.

F.11.2 The FORM Specification for External Files

The FORM specification for external Files created by TEXT_IO include the default (i.e., the NULL string) and the two shorthand strings: "PASS ALL" or "LOG FILE". The only FORM specification for external files created by SEQUENTIAL_IO and DIRECT_IO is the default of the NULL string. Note that opening the external file after its creation still utilizes the file attributes assigned to the file when it was created and, therefore, the only legal FORM specification is the NULL string.

An allowable FORM string in TEXT_IO has syntax defined by the grammar is shown in Table F-1 below. The tokens of the grammar may be separated by any combination of blanks (' ') and horizontal tab (ASCII.HT) characters. The FORM parameter is not case sensitive, but repetition of a file attribute item is not allowed. The record format values valid with the file organization SEQUENTIAL are: STREAM, STREAM_CARRIAGE_RETURN, STREAM_LINE_FEED, and UNDEFINED. Note that the VARIABLE FIXED CONTROL record format is not valid with the INDEXED file organization.

In TEXT_IO, the following default FORM value is assumed when the FORM parameter is the NULL string:

```
"RECORD FORMAT := VARIABLE, " &  
"FILE ORGANIZATION := SEQUENTIAL, " &  
"CARRIAGE_CONTROL := CARRIAGE_RETURN"
```

The "PASS_ALL" FORM parameter is equivalent to the string:

```
"RECORD FORMAT := VARIABLE, " &  
"FILE ORGANIZATION := SEQUENTIAL, " &  
"CARRIAGE_CONTROL := NONE"
```

The "LOG_FILE" FORM parameter is equivalent to the string:

```
"RECORD FORMAT := VARIABLE FIXED CONTROL, " &  
"FILE ORGANIZATION := SEQUENTIAL, " &  
"CARRIAGE_CONTROL := PRINT"
```

| Left Hand Side | Right Hand Side |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------|
| form_string | == "" shorthand_string file_attribute_list |
| shorthand_string | == PASS_ALL LOG_FILE |
| file_attribute_list | == file_attribute_item {,file_attribute_item} |
| file_attribute_item | == record_format_string file_organization_string carriage_control_string |
| record_format_string | == RECORD_FORMAT := record_format |
| record_format | == VARIABLE FIXED STREAM VARIABLE_FIXED_CONTROL STREAM_CARRIAGE_CONTROL STREAM_LINE_FEED UNDEFINED |
| file_organization_string | == FILE_ORGANIZATION := file_organization |
| file_organization | == SEQUENTIAL RELATIVE INDEXED |
| carriage_control_string | == CARRIAGE_CONTROL := carriage_control |
| carriage_control | == FORTRAN CARRIAGE_RETURN PRINT NONE |

Table F-1 - FORM String Grammar

.

F.11.3 External File Processing

Section 14 of the Ada LRM defines two kinds of access to external files: sequential access and direct access. A file object used for sequential access is called a sequential file, and one used for direct access is called a direct file. Three file modes are defined: `IN_FILE`, `OUT_FILE`, and `INOUT_FILE`. All three file modes are allowed for direct files, whereas only the modes `IN_FILE` and `OUT_FILE` are allowed for sequential files.

AdaVAX takes the view that files of mode `IN_FILE` already contain data, making them suitable for reading, while files of mode `OUT_FILE` are empty, making them suitable for writing. Files of mode `INOUT_FILE` may contain data or may be empty, making them suitable for reading or writing. An attempt to create a file of mode `IN_FILE` will raise the exception `USE_ERROR` since a newly created file is empty (i.e., not suitable for reading). Stated more simply, AdaVAX restricts the creation of files to those of mode `OUT_FILE` or `INOUT_FILE`.

Processing allowed on external files is determined by the access controls set by the owner of the file and by the physical characteristics of the underlying device. The following restrictions apply:

- a. A user may open a file as an `IN_FILE` only if that user has read access to the node. A user may open a file as an `OUT_FILE` only if that user has write access to the node. Finally, a user may open a file as an `INOUT_FILE` only if that user has read and write access to the node.
- b. The attempt to `CREATE` a file with the mode `IN_FILE` is not supported since there will be no data in the file to read.
- c. Multiple `OPENS` are allowed to read from a file, but all `OPENS` to write require exclusive access to the file. The exception `USE_ERROR` is raised if this restriction is violated.
- d. No positioning operations are allowed on files associated with a printer or hard-copy terminal. The exception `USE_ERROR` is raised if this restriction is violated.

F.11.4 Text Input/Output

The specification of TEXT_IO is given by Section 14.3.10 of the Ada LRM. TEXT_IO is invoked by the Ada task to perform sequential access I/O operations on text files (i.e., files whose content is in a human-readable form). TEXT_IO is not a generic package, and thus, its subprograms may be invoked directly from the Ada task, using objects with base type or parent type in the language-defined type CHARACTER (and of course STRING). TEXT_IO also provides the generic packages INTEGER_IO, FLOAT_IO, FIXED_IO and ENUMERATION_IO for the reading and writing of numeric values and enumeration values. The generic packages within TEXT_IO require an instantiation for a given element type before any of their subprograms are invoked.

The implementation-defined type COUNT that appears in Section 14.3.10 of the Ada LRM is defined as follows:

```
type COUNT is range 0..LONG_INTEGER'LAST;
```

The implementation-defined subtype FIELD that appears in Section 14.3.10 of the Ada LRM is defined as follows:

```
subtype FIELD is INTEGER range 0..INTEGER'LAST;
```

At the beginning of program execution, the STANDARD_INPUT file and the STANDARD_OUTPUT file are open and associated with the ALS/N-supported standard input and output files. The STANDARD_INPUT and STANDARD_OUTPUT file cannot be deleted, attempts to do so raise the exception USE_ERROR. Additionally, if a program terminates before an open file is closed (except for STANDARD_INPUT and STANDARD_OUTPUT), then the last line the user put to the file may be lost.

A program is erroneous if concurrently executing tasks attempt to perform overlapping GET and/or PUT operations on the same terminal. Because of the physical nature of DecWriters and Video terminals, the semantics of text layout as specified in Ada Language Reference Manual Section 14.3.2 (especially the concepts of current column number and current line) cannot be guaranteed when GET operations are interweaved with PUT operations. Programs that rely on the semantics of text layout under those circumstances are erroneous.

For TEXT_IO processing, the line length can be no longer than the maximum VAX/VMS record length minus one (i.e., 255 characters). An attempt to write over the record length boundary will result in writing a full record and starting a new record. An attempt to set the line length through SET_LINE_LENGTH to a length greater than 255 will result in USE_ERROR. An attempt to read a file with a line length greater than 255 will also result in a USE_ERROR.

F.11.5 Sequential Input/Output

The specification of SEQUENTIAL_IO is given in Section 14.2.3 of the Ada LRM. SEQUENTIAL_IO is invoked by the Ada task to perform I/O of the records of a file in an arbitrary order. The package SEQUENTIAL_IO requires a generic instantiation for a given element type before any of its subprograms may be invoked. Once the package SEQUENTIAL_IO is made visible, it will perform any service defined by the subprograms declared in its specification.

The following restrictions are imposed on the use of the package Sequential_IO:

- a. A null file name parameter to the CREATE procedure (for opening a temporary file) is not appropriate, and raises the exception NAME_ERROR.
- b. Writing a record on a file associated with a tape adds the record to the file such that the record just written becomes the last record of the file.
- c. On a disk or tape, the DELETE procedure closes the file and sets its size to zero so that its data may no longer be accessed.
- d. The subprogram END_OF_FILE always returns FALSE for a character-oriented device and RESET performs no action on a character-oriented device.

F.11.6 Direct Input/Output

The specification of DIRECT_IO is given in Section 14.2.5 of the Ada LRM. DIRECT_IO is invoked by the Ada task to perform I/O of the records of a file in an arbitrary order. The package DIRECT_IO requires a generic instantiation for a given element type before any of its subprograms may be invoked. Once the package DIRECT_IO is made visible, it will perform any service defined by the subprograms declared in its specification.

The implementation-defined type COUNT that appears in Section 14.2.5 of the Ada LRM is defined as follows:

```
type COUNT is range 0..LONG_INTEGER'LAST;
```

F.11.7 Low Level Input/Output

The package LOW_LEVEL_IO defines a standard interface to allow an application to interact directly with a physical device. LOW_LEVEL_IO provides a definition of data types for a physical device and data to be operated on, along with the standard procedures SEND_CONTROL and RECEIVE_CONTROL. The procedure SEND_CONTROL may be used to send control information to a physical device. RECEIVE_CONTROL may be used to monitor the execution of an I/O operation by requesting information from a physical device.

with SYSTEM;

package LOW_LEVEL_IO is

```
type IO_BUFFER_ADDRESS is new SYSTEM.ADDRESS;
type IO_BUFFER_COUNT is new INTEGER;
type IO_TIME_OUT is new INTEGER;

type IO_FUNCTION is (
  read_data,      -- read data
  write_data,     -- write data
  initialize,     -- initialize the device and
                  -- return the device_code
  cancel,         -- cancel IO request
  control);       -- return control information

type DEVICE_TYPE is new LONG_INTEGER;
DEVICE_NAME_LENGTH: constant INTEGER := 32;

type IO_REQUEST_BLOCK is record
  REQUESTED_FUNCTION: IO_FUNCTION;
  DEVICE_NAME:       STRING(1..DEVICE_NAME_LENGTH);
  DEVICE:            DEVICE_TYPE;
  BUFFER_ADDRESS:    IO_BUFFER_ADDRESS;
  BUFFER_COUNT:      IO_BUFFER_COUNT;
  TIME_OUT:          IO_TIME_OUT;
end record;
```

```

type IO_RETURN_STATUS is (
    ss_normal,          -- normal completion
    ss_abort,           -- all "failure" status codes
    ss_accvio,
    ss_devoffline,
    ss_exquota,
    ss_illefc,
    ss_insfmem,
    ss_ivchan,
    ss_nopriv,
    ss_unasefc,
    ss_linkabort,
    ss_linkdiscon,
    ss_protocol,
    ss_conneccfail,
    ss_filalracc,
    ss_invlogin,
    ss_indevnam,
    ss_linkexit,
    ss_nolinks,
    ss_nosuchnode,
    ss_reject,
    ss_remrsrc,
    ss_shut,
    ss_toomuchdata,
    ss_unreachable);

type IO_STATUS_BLOCK is record
    BYTE_COUNT:          IO_BUFFER_COUNT;
    RETURNED_STATUS:      IO_RETURN_STATUS;
end record;

procedure SEND_CONTROL (DEVICE: in  DEVICE_TYPE;
                        DATA: in out IO_REQUEST_BLOCK);

procedure RECEIVE_CONTROL (DEVICE: in  DEVICE_TYPE;
                           DATA: in out IO_STATUS_BLOCK);

end LOW_LEVEL_IO;

```

F.12 System Defined Exceptions

In addition to the exceptions defined in the Ada Language Reference Manual, this implementation pre-defines the exceptions shown in Table F-2 below.

| Name | Significance |
|----------------------|-----------------------------------------------------------------------------|
| ACCESS_CHECK | The ACCESS_CHECK exception has been raised explicitly within the program. |
| DISCRIMINANT_CHECK | DISCRIMINANT_CHECK exception has been raised explicitly within the program. |
| INDEX_CHECK | The INDEX_CHECK exception has been raised explicitly within the program. |
| LENGTH_CHECK | The LENGTH_CHECK exception has been raised explicitly within the program. |
| RANGE_CHECK | The RANGE_CHECK exception has been raised explicitly within the program. |
| DIVISION_CHECK | The DIVISION_CHECK exception has been raised explicitly within the program. |
| OVERFLOW_CHECK | The OVERFLOW_CHECK exception has been raised explicitly within the program. |
| ELABORATION_CHECK | ELABORATION_CHECK exception has been raised explicitly within the program. |
| STORAGE_CHECK | The STORAGE_CHECK exception has been raised explicitly within the program. |
| UNRESOLVED_REFERENCE | Attempted call to a routine not linked into the executable image. |
| SYSTEM_ERROR | Serious error detected in underlying VAX/VMS operating system. |

Table F-2 - System Defined Exceptions

F.13 Machine Code Insertions

The Ada language definition permits machine code insertions as described in Section 13.8 of the Ada Language Reference Manual. This section describes the implementation specific details for writing machine code insertions as provided by the predefined library package `MACHINE_CODE`.

The user may, if desired, include `MACRO` instructions within an Ada program. This is done by including a subprogram in the program which contains only record aggregates defining machine code instructions. The package `MACHINE_CODE`, included in the system program library, contains type, record and constant declarations which are used to form the instructions. Each field of the aggregate contains a field of the resulting machine instruction. These fields are specified in the order in which they appear in the actual instruction. Records for one- and two- byte instruction codes are available. Each instruction record is discriminated using the instruction code. The record components determined by the discriminant are the arguments of the record. Arguments are represented using records whose discriminants are called address modes. The discriminant determines what additional information (if any) must be associated with the argument. Separate records are available for specifying data.

```
WITH machine_code;
USE machine_code;
FUNCTION fixed_multiply
  (multiplier_1 : IN LONG_INTEGER; -- in R0
   multiplier_2 : IN LONG_INTEGER; -- in R1
   scaling_factor : IN LONG_INTEGER -- in R2
  ) RETURN LONG_INTEGER IS -- in R0
BEGIN
  -- EMUL R0, R1, #0, R0
  -- named aggregate notation
  byte_op_code
    (op => emul,
     emul_1 => long_word_general_operand(op => R0),
     emul_2 => long_word_general_operand(op => R1),
     emul_3 => long_word_general_operand(op => L0),
     emul_4 => quad_word_general_operand(op => R0));
  -- ASHQ R2, R0, R0
  -- positional notation
  byte_op_code
    (ashq,
     byte_word_general_operand(op => R2),
     quad_word_general_operand(op => R0),
     quad_word_general_operand(op => R2));
END fixed_multiply;
```

Note that either positional or named aggregates may be used.

ALS/N supports machine code insertions through calls to procedures whose bodies are composed of sequences of assembly language instructions. Each instruction in the sequence is specified as an aggregate of either the record type `BYTE_OP_CODE` or `WORD_OP_CODE`, both declared in the Runtime Support Library package `MACHINE_CODE`. These types are variant records whose discriminant is a symbolic VAX-11 instruction opcode. Components of each discriminated record correspond to the instruction operands appropriate to a given instruction opcode. Components of `BYTE_OP_CODE` and `WORD_OP_CODE` are themselves variant records. Their discriminated components are used to specify operand addressing modes together with needed registers, displacements and literal values. The type mark `BYTE_OP_CODE` is used for those VAX-11 instructions whose opcodes can be represented in a single byte (e.g., `MOVL`). `WORD_OP_CODE` is used for those VAX-11 instructions whose opcodes consume two bytes (e.g., `CMPH`).

These ideas are illustrated in Figure F-1 below. A more detailed explanation of how machine code insertions are composed for the VAX target is given in this section. In this example the procedure `TIMES_TWO` is used to double integer valued objects. It effects a multiplication of its single argument using the Arithmetic Shift Logical instruction, `ASHL`. The value to be multiplied is passed by reference to the procedure `TIMES_TWO` and can be found four bytes away from the address held in the Argument Pointer, `AP`. Using byte displacement deferred addressing mode (i.e., `IB AP`) to access the procedure argument allows the shift by one bit to occur "in place".

```
with MACHINE_CODE ; use MACHINE_CODE ;
procedure TIMES_TWO(value : IN OUT integer) is
begin

    BYTE_OP_CODE'(OP => ASHL,                -- Instruction = ASHL
        ASHL_1 => (OP => IMD, B_IMD => 1),    -- Operand 1 = "#1"
        ASHL_2 => (OP => IB_AP, BYTE_DISP => 4), -- Operand 2 = @4(AP)
        ASHL_3 => (OP => IB_AP, BYTE_DISP => 4) -- Operand 3 = @4(AP)
    );

end TIMES_TWO ;
```

Figure F-1 - Machine Code Insertion

F.13.1 Machine Features

This paragraph describes specific machine language features needed to write code statements. These machine features include the DISP and ADDRESS attributes and the address mode specifiers. The address mode specifiers make it possible to describe both the address mode and register number of any operand as a single value by mapping these values directly onto the first byte of each operand. The following is an enumeration of all mode specifiers:

```
--
-- The first 64 are the short literal modes.
-- These mode specifiers signify (short literal mode, value)
-- combinations. The values are in the range 0 to 63.
--
```

| | | | |
|------|------|------|------|
| L0, | L1, | L2, | L3, |
| L4, | L5, | L6, | L7, |
| L8, | L9, | L10, | L11, |
| L12, | L13, | L14, | L15, |
| L16, | L17, | L18, | L19, |
| L20, | L21, | L22, | L23, |
| L24, | L25, | L26, | L27, |
| L28, | L29, | L30, | L31, |
| L32, | L33, | L34, | L35, |
| L36, | L37, | L38, | L39, |
| L40, | L41, | L42, | L43, |
| L44, | L45, | L46, | L47, |
| L48, | L49, | L50, | L51, |
| L52, | L53, | L54, | L55, |
| L56, | L57, | L58, | L59, |
| L60, | L61, | L62, | L63, |

--
-- Next are the (index mode, register) combinations.
--

| | | | |
|-------|-------|--------|--------|
| X_R0, | X_R1, | X_R2, | X_R3, |
| X_R4, | X_R5, | X_R6, | X_R7, |
| X_R8, | X_R9, | X_R10, | X_R11, |
| X_AP, | X_FP, | X_SP, | X_PC, |

--
-- The following are the (register mode, register) combinations.
--

| | | | |
|-----|-----|------|------|
| R0, | R1, | R2, | R3, |
| R4, | R5, | R6, | R7, |
| R8, | R9, | R10, | R11, |
| AP, | FP, | SP, | PC, |

--
-- The following are the (indirect register mode, register)
-- combinations.
--

| | | | |
|------|------|-------|-------|
| IR0, | IR1, | IR2, | IR3, |
| IR4, | IR5, | IR6, | IR7, |
| IR8, | IR9, | IR10, | IR11, |
| IAP, | IFP, | ISP, | IPC, |

--
-- Next are the (autodecrement register mode, register)
-- combinations.
--

| | | | |
|---------|---------|----------|----------|
| DEC_R0, | DEC_R1, | DEC_R2, | DEC_R3, |
| DEC_R4, | DEC_R5, | DEC_R6, | DEC_R7, |
| DEC_R8, | DEC_R9, | DEC_R10, | DEC_R11, |
| DEC_AP, | DEC_FP, | DEC_SP, | DEC_PC, |

--
-- Next are the (autoincrement register mode, register)
-- combinations. IMD (immediate mode) is autoincrement
-- mode using the PC.
--

| | | | |
|---------|---------|----------|----------|
| R0_INC, | R1_INC, | R2_INC, | R3_INC, |
| R4_INC, | R5_INC, | R6_INC, | R7_INC, |
| R8_INC, | R9_INC, | R10_INC, | R11_INC, |
| AP_INC, | FP_INC, | SP_INC, | IMD, |

--
-- The following are the (autoincrement deferred mode, register)
-- combinations. A (absolute address mode) is autoincrement
-- deferred using the PC.
--

| | | | |
|----------|----------|-----------|-----------|
| IR0_INC, | IR1_INC, | IR2_INC, | IR3_INC, |
| IR4_INC, | IR5_INC, | IR6_INC, | IR7_INC, |
| IR8_INC, | IR9_INC, | IR10_INC, | IR11_INC, |
| IAP_INC, | IFP_INC, | ISP_INC, | A, |

--
 -- The following are the (byte-displacement mode, register)
 -- combinations. B_PC is byte-relative mode for the PC.
 --

| | | | |
|-------|-------|--------|--------|
| B_R0, | B_R1, | B_R2, | B_R3, |
| B_R4, | B_R5, | B_R6, | B_R7, |
| B_R8, | B_R9, | B_R10, | B_R11, |
| B_AP, | B_FP, | B_SP, | B_PC, |

--
 -- Next are the (byte-displacement deferred mode, register)
 -- combinations. IB_PC is byte-relative deferred mode for
 -- the PC.
 --

| | | | |
|--------|--------|---------|---------|
| IB_R0, | IB_R1, | IB_R2, | IB_R3, |
| IB_R4, | IB_R5, | IB_R6, | IB_R7, |
| IB_R8, | IB_R9, | IB_R10, | IB_R11, |
| IB_AP, | IB_FP, | IB_SP, | IB_PC, |

--
 -- The following are the (word-displacement mode, register)
 -- combinations. W_PC is word relative mode for the PC.
 --

| | | | |
|-------|-------|--------|--------|
| W_R0, | W_R1, | W_R2, | W_R3, |
| W_R4, | W_R5, | W_R6, | W_R7, |
| W_R8, | W_R9, | W_R10, | W_R11, |
| W_AP, | W_FP, | W_SP, | W_PC, |

--
 -- The following are the (word-displacement deferred mode,
 -- register) combinations. IW_PC is word relative deferred
 -- mode for the PC.
 --

| | | | |
|--------|--------|---------|---------|
| IW_R0, | IW_R1, | IW_R2, | IW_R3, |
| IW_R4, | IW_R5, | IW_R6, | IW_R7, |
| IW_R8, | IW_R9, | IW_R10, | IW_R11, |
| IW_AP, | IW_FP, | IW_SP, | IW_PC, |

--
 -- Next are the (longword-displacement mode, register)
 -- combinations. L_PC is longword-relative mode.
 --

| | | | |
|-------|-------|--------|--------|
| L_R0, | L_R1, | L_R2, | L_R3, |
| L_R4, | L_R5, | L_R6, | L_R7, |
| L_R8, | L_R9, | L_R10, | L_R11, |
| L_AP, | L_FP, | L_SP, | L_PC, |

--
 -- The following are the (longword-displacement deferred mode,
 -- register) combinations. IL_PC is longword-relative deferred
 -- mode.
 --

| | | | |
|--------|--------|---------|---------|
| IL_R0, | IL_R1, | IL_R2, | IL_R3, |
| IL_R4, | IL_R5, | IL_R6, | IL_R7, |
| IL_R8, | IL_R9, | IL_R10, | IL_R11, |
| IL_AP, | IL_FP, | IL_SP, | IL_PC); |

F.13.2 ADDRESS and DISP Attributes

The following restriction applies to the use of the ADDRESS and DISP attributes:

- a. All displacements and addresses (i.e., branch destinations, program counter addressing mode displacements, etc.) must be static expressions.
- b. Since neither the ADDRESS nor the DISP attributes return static values, they can not be used in code statements within the Ada compilation unit.

F.13.3 Restrictions on Assembler Constructs

These unsupported Assembler constructs within the MACHINE_CODE package are as follows:

- a. The VAX/VMS assembler's capability to compute the length of immediate and literal data is not replicated in MACHINE_CODE. This means the user cannot supply a value without specifying the length of that value. This disallows the assembler operand general formats: D(R), G, G^G, #cons, #cons[Rx], D(R)[Rx], G[Rx], G^location[Rx], @D(R)[Rx], @G[Rx], @D(R), @G such that D and G are byte, word, or long word values. Operands must contain address mode specifiers which explicitly define the length of any immediate or literal values of that operand.
- b. The radix of the assembler notation is decimal. To express a hexadecimal literal, the notation 16#literal# should be used instead of ^X.
- c. To construct an octaword, quadword, g_float or h_float number, it is important for the user to remember that the component fields of the records that make up the long numeric types are signed. This means that the user must take care to be assured that the values for these components, although signed, are interpreted correctly by the instruction set architecture.
- d. Edit instruction streams must be constructed through the use of the VAX data statements described in Section 6.12.3.

- e. Compatibility mode instruction streams must be constructed through the use of the VAX data statements described in Section 6.12.3, if still supported on the VAX computer being utilized as the target machine (i.e., VAX-11/780 and 785, but not the VAX-8600).
- f. No error messages are generated if the PC is used as the register for operands taking a single register, if the SP or PC are used for operands taking two registers, or if the AP, FP, SP, or PC is used for operands taking four registers.
- g. No error message is generated if the PC is used in register deferred or autodecrement mode.
- h. If any register other than the PC is used as both the `simple_operand` and as the `index_reg` for an operand (see Section 6.14.1.2 for definitions of `simple_operand` and `index_reg`), no error message is generated. An example of this case is the VAX Assembler operand (7)[7].
- i. Generic opcode selection is not supported. This means the opcode which reflects the specified number of operands must be used. For example, for 2 operand word addition, `ADDW2` must be used, not just `ADDW`.
- j. The PC is not supplied as a default if no register is specified in an operand. The user must supply the mode specifier which is mapped onto the PC. Examples are `IMD`, `A`, `B_PC`, `W_PC`, etc.

F.14 Machine Instructions and Data

This section describes the syntactic details for writing code statements (machine code insertions) as provided for the VAX by the pre-defined package MACHINE_CODE. The format for writing code statements is detailed, as are descriptions of the values to be supplied in the code statements. Each value is described by the named association for that value and its defined in the order in which it must appear in positional notation. The programmer should refer to the VAX-11 Architecture Handbook along with this section to ensure that the machine instructions are correct from an architectural viewpoint.

To ensure a proper interface between Ada and machine code insertions, the user must be aware of the calling conventions used by the Ada compiler.

F.14.1 VAX Instructions

The general format for VAX code statements where the opcode is a one byte opcode is

```
BYTE_OP_CODE (OP => opcode {,"opcode" 1 => operand
                             {,"opcode" 2 => operand
                             {,"opcode" 3 => operand
                             {,"opcode" 4 => operand
                             {,"opcode" 5 => operand
                             {,"opcode" 6 => operand}}}}}});
```

The general format for VAX code statements where the opcode is a two byte opcode is

```
WORD_OP_CODE (OP => opcode2 {,"opcode2" 1 => operand
                              {,"opcode2" 2 => operand
                              {,"opcode2" 3 => operand
                              {,"opcode2" 4 => operand
                              {,"opcode2" 5 => operand
                              {,"opcode2" 6 => operand}}}}}});
```

where "opcode" _n and "opcode2" _n is the result of the concatenation of the VAX opcode, an underscore, and the position of the operand in the VAX instruction. The BYTE_OP_CODE and WORD_OP_CODE statements always require an opcode and may include from one to six operands. The opcode mnemonics are precisely the same as described in the previously referenced VAX-11 Architecture Handbook. The VAX address modes divide the operands into six general categories: Short Literal Operand, Indexed Operand, Register Operand, Byte-Displacement Operand, Word-Displacement Operand, and Long_Word-Displacement Operand.

F.14.1.1 Short Literal Operands

The VAX/VMS Assembler format for short literal operands is

`S^#cons`

where `cons` is an integer constant with a range from 0 to 63 (decimal).

The code statement format for short literal operands is

`(OP => short_lit)`

where `short_lit` is one of the enumerated values, range L0 to L63, of the address mode specifiers in Section 6.11.1.

The following are examples of how some VAX Assembler short literals would be expressed in code statements:

`S^#7` becomes `(OP => L7)`
`S^#33` becomes `(OP => L33)`
`S^#60` becomes `(OP => L60)`

(For explanations of named and unnamed component association, see Section 4.3 of the Ada Language Reference Manual.)

F.14.1.2 Indexed Operands

The VAX/VMS Assembler format for the indexed operands is

`simple_operand[Rx]`

where a `simple_operand` is an operand of any address mode except register, literal, or index.

The general code statement format for indexed operands is

`(index_reg, simple_operand) or`
`(OP => index_reg, OPND => simple_operand)`

where `index_reg` is one of the enumerated address mode specifiers, range X_R0 to X_SP, from Section 6.11.1. `Simple_operand` is an operand of any address mode except register, literal, or index.

For example, the following are indexed assembler operands:

- a. (R8)[R7] becomes (X_R7, (OP => IR8))
- b. (R8)+[R7] becomes (X_R7, (OP => R8_INC))
- c. I^#600[R4] becomes (X_R4, (IMD,600))
- d. -(R4)[R3] becomes (X_R3, (OP => DEC_R4))
- e. B^4(R9)[R3] becomes (X_R3, (B_R9,4))
- f. W^800(R8)[R5] becomes (X_R5, (W_R8,800))
- g. L^34000(R8)[R4] becomes (X_R4, (L_R8,34000))
- h. B^10[R9] becomes (X_R9, (B_PC,10))
- i. W^130[R2] becomes (X_R2, (W_PC,130))
- j. L^35000[R6] becomes (X_R6, (L_PC,35000))
- k. @(R3)+[R5] becomes (X_R5, (OP => IR3_INC))
- l. @#1432[R5] becomes (X_R5, (A,1432))
- m. @B^4(R9)[R3] becomes (X_R3, IB_R9,4))
- n. @W^8(R8)[R5] becomes (X_R5, (IW_R8,8))
- o. @L^2(R8)[R4] becomes (X_R4, (IL_R8,2))
- p. @B^3[R1] becomes (X_R1, (IB_PC,3))
- q. @W^150[R2] becomes (X_R2, (IW_PC,150))
- r. @L^100000[R3] becomes (X_R3, (IL_PC,100000))

Then would be expressed in named notation as:

- a. (OP => X_R7, OPND => (OP => IR7))
- b. (OP => X_R7, OPND => (OP => R8_INC))
- c. (OP => X_R4, OPND => (OP => IMD, W_IMD => 600))
- d. (OP => X_R3, OPND => (OP => DEC_R4))
- e. (OP => X_R3, OPND => (OP => B_R9, BYTE_DISP => 4))
- f. (OP => X_R5, OPND => (OP => W_R8, WORD_DISP => 800))
- g. (OP => X_R4, OPND => (OP => L_R8,
LONG_WORD_DISP => 34000))
- h. (OP => X_R9, OPND => (OP => B_PC, BYTE_DISP => 10))
- i. (OP => X_R2, OPND => (OP => W_PC, WORD_DISP => 130))
- j. (OP => X_R6, OPND => (OP => L_PC,
LONG_WORD_DISP => 35000))
- k. (OP => X_R5, OPND => (OP => IR3_INC))
- l. (OP => X_R5, OPND => (OP => A, ADDR => 1432))
- m. (OP => X_R3, OPND => (OP => IB_R9, BYTE_DISP => 4))
- n. (OP => X_R5, OPND => (OP => IW_R8, WORD_DISP => 8))
- o. (OP => X_R4, OPND => (OP => IL_R8,
LONG_WORD_DISP => 2))
- p. (OP => X_R1, OPND => (OP => IB_PC, B_DISP => 3))
- q. (OP => X_R2, OPND => (OP => IW_PC, WORD_DISP => 150))
- r. (OP => X_R3, OPND => (OP => IL_PC,
LONG_WORD_DISP => 100000))

F.14.1.3 Register Operands

The VAX/VMS Assembler formats for register operands are

| | |
|--------|--------------------------------|
| Rn | -- Register mode |
| (Rn) | -- Register deferred mode |
| -(Rn) | -- Autodecrement mode |
| (Rn)+ | -- Autoincrement mode |
| @(Rn)+ | -- Autoincrement deferred mode |

where Rn represents a register numbered from 0 to 15.

The general code statement format for register operands is

(OP => regmode_value)

where regmode_value represents one of the enumerated address mode specifier range R0 to PC, from Section 6.11.1.

The following are examples of how VAX/VMS Assembler register mode operands would be written as code statements:

| | | |
|--------|---------|-----------------|
| R7 | becomes | (OP => R7) |
| (R8) | becomes | (OP => IR8) |
| -(R9) | becomes | (OP => DEC_R9) |
| (R1)+ | becomes | (OP => R1_INC) |
| @(R3)+ | becomes | (OP => IR3_INC) |

F.14.1.4 Byte-Displacement Operands

The VAX/VMS Assembler syntax for the byte-displacement operands is

| | |
|----------|------------------------------------|
| B^d(Rn) | -- Byte-displacement mode |
| @B^d(Rn) | -- Byte-displacement deferred mode |

where d is the displacement added to the contents of register Rn. If no register is specified, the program counter is assumed. The code statement general format for the byte-displacement and byte-displacement deferred modes is

(byte_disp_spec, value)
or
(OP => byte_disp_spec, BYTE_DISP => value)

where byte_disp_spec is one of the enumerated address mode specifiers, range B_R0 to B_PC for byte-displacement or IB_R0 to IB_PC for byte displacement deferred, from Section 6.11.1. Value is in the range -128 to 127.

The following are examples of how VAX/VMS Assembler byte-displacement operands would be written in code statements:

```

B^4(R5)      becomes (B_R5, 4)      or
                (OP => B_R5, BYTE_DISP => 4)
B^200(R5)    becomes (B_R5, 200)    or
                (OP => B_R5, BYTE_DISP => 200)
B^33         becomes (B_PC, 33)     or
                (OP => B_PC, BYTE_DISP => 33)
@B^4(R5)     becomes (IB_R5, 4)     or
                (OP => IB_R5, BYTE_DISP => 4)
@B^200(R5)   becomes (IB_R5, 200)   or
                (OP => IB_R5, BYTE_DISP => 200)
@B^33        becomes (IB_PC, 33)    or
                (OP => IB_PC, BYTE_DISP => 33)

```

F.14.1.5 Word-Displacement Operands

The VAX/VMS Assembler syntax for the word-displacement operands are

```

W^d(Rn)      -- Word-displacement
@W^d(Rn)     -- Word-displacement deferred

```

where d is the displacement to be added to the contents of register Rn. If no register is specified, the program counter is assumed. In code statements, word displacement operands are represented in general as

```

(word_disp_spec, value)
or
(OP => word_disp_spec, WORD_DISP => value)

```

where word_disp_spec is one of the enumerated address mode specifiers, range W_R0 to W_PC for word-displacement mode or IW_R0 or IW_PC for word-displacement deferred mode, from Section 6.11.1. Value is in the range $-2^{*}15$ to $2^{*}15 - 1$.

The following are examples of how VAX/VMS Assembler word-displacement operands would be written in code statements:

```

W^10(R5)     becomes (W_R5, 10)    or
                (OP => W_R5, WORD_DISP => 10)
W^20         becomes (W_PC, 20)    or
                (OP => W_PC, WORD_DISP => 20)
@W^128(R7)   becomes (W_R7, 128)   or
                (OP => IW_R7, WORD_DISP => 128)
@W^324       becomes (W_PC, 324)   or
                (OP => IW_PC, WORD_DISP => 324)

```

F.14.1.6 Long_Word-Displacement Operands

The VAX/VMS Assembler general formats for the long_word-displacement operands is

| | |
|----------------------|------------------------------------|
| L ^d (Rn) | -- Long_word-displacement |
| @L ^d (Rn) | -- Long_word-displacement deferred |

where d is the displacement to be added to the register represented by Rn. Long_word-displacement operands are represented in code statements by the general format

(lword_disp_spec, value)
or
(OP => lword_disp_spec, LONG_WORD_DISP => value)

where lword_disp_spec is one of the enumerated address mode specifiers, range L R0 to L PC for long_word-displacement mode or IL R0 to IL PC for long_word-displacement deferred mode, from Section 6.11.1. Value is in the range -2**31 to 2**31 - 1.

The following are examples of how VAX/VMS Assembler long_word-displacement operands would be written in code statements:

| | | |
|-------------------------|---------|---------------------------------------|
| L ¹⁰⁰⁰ (R7) | becomes | (L R7, 1000) or |
| | | (OP => L_R7, LONG_WORD_DISP => 1000) |
| L ²⁵⁰⁰⁰ | becomes | (L PC, 25000) or |
| | | (OP => L_PC, LONG_WORD_DISP => 25000) |
| @L ¹⁰⁰⁰ (R9) | becomes | (IL R9, 1000) or |
| | | (OP => IL_R9, LONG_WORD_DISP => 1000) |
| @L ³⁵⁰⁰ | becomes | (IL PC, 3500) or |
| | | (OP => IL_PC, LONG_WORD_DISP => 3500) |

F.14.2 The CASE Statement

The VAX case statements (mnemonics CASEB, CASEW, and CASEL) have the following general symbolic form

opcode selector.rx, base.rx, limit.rx,
displ[0].bw, .. , displ[limit].bw

where x is dependent upon the opcode as to whether the operand is of type BYTE, WORD, or LONG WORD. Displ[0].bw, .. , displ[limit].bw is a list of displacements to which to branch. Case statements would be written as code statements as:

```

BYTE_OP_CODE(OP => case_opcode, "case_opcode"_1=> operand,
             "case_opcode"_2 => operand,
             "case_opcode"_3 => case_operand)

```

where case_opcode is one of CASEB, CASEW, or CASEL. The type of operand and case_operand are as indicated in the opcode (BYTE, WORD, or LONG_WORD). A case_operand is a special case operand of the form:

```

case_operand => (case_limit_address_mode, (case_enum))
               or
case_operand => (LIMIT => case_limit_address_mode,
               (CASES=>case_enum))

```

if case_limit_address_mode is one of the short literal address specifiers. If case_limit_address_mode is the mode specifier IMD, the case_operand takes the form:

```

case_operand => (IMD, (case_limit, (case_enum)))
               or
case_operand => (LIMIT => IMD, CASE_LIST =>
               (LIMIT => case_limit, (CASES => case_enum)))

```

where case_operand is one of BYTE_CASE_OPERAND, WORD_CASE_OPERAND, or LONG_WORD_CASE_OPERAND. The case_limit_address_mode is one of the short literal mode specifiers or the mode specifier IMD. Case_enum is a list of branch addresses. The branch addresses must be of type WORD. The case_limit is a value of the type indicated by the case_opcode.

Some examples of case statements written as code statements are:

```

<<START>>      BYTE_OP_CODE(CASEB, (OP =>R3, (IMD, 5), (IMD
               (2,(15,30,45))))); -- Case statement using
                                   -- immediate mode.

S2             BYTE_OP_CODE(CASEW, (OP => (W_PC, 10)), (IMD, 100),
               (L2,(10,20,30))); -- Case statement using
                                   -- short literal mode.

```


F.14.3 VAX Data

Constant values such as absolute addresses or displacements may be entered into the code stream with any of these nine statements:

```
BYTE_VALUE'(byte)
WORD_VALUE'(word)
LONG_WORD_VALUE'(long_word)
QUADWORD_VALUE'(quadword)
OCTAWORD_VALUE'(octaword)
FLOAT_VALUE'(float)
LONG_FLOAT_VALUE'(long_float)
G_FLOAT_VALUE'(g_float)
H_FLOAT_VALUE'(h_float)
```